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PATENT SPECIFICATION

753,603

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COMPLETE SPECIFICATION.

Improvements in and relating to the Manufacture of Films.

We, IMPERIAL CHEMICAL INDUSTRIES LIMITED, of Imperial Chemical House, Millbank, London, London, S.W.1, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a process for cold-drawing films of organic thermoplastic material. By the term "cold-drawing" as used throughout this Specification, we mean stretching the film at a temperature below the melting point of the thermoplastic material. Cold-drawing is frequently assisted, however, by heating the film to a temperature well above room temperature. The purpose of cold-drawing is to cause molecular orientation in the film and in this way improve its properties.

It is preferred that the orientation of films should be both longitudinal and lateral as the film then shows improved properties in all directions over its surface. Films of organic thermoplastic material may be drawn longitudinally as a continuous process by passing them from one set of pinch rolls to a second set of pinch rolls operating at a higher speed, or by similar methods. Transverse or lateral drawing may be carried out as a continuous process by gripping the edges of the film and gradually separating them as the film moves along a given path; it has previously been proposed to assist drawing in this process by heating the whole of the section of the film undergoing drawing, for example by radiant heaters or by carrying out the drawing process in an air oven. The equipment used for gripping the film may take a number of different forms. For example, tenter clips or hooks may be adapted to hold the edges of the film while they diverge at a predetermined rate to impart the desired amount of transverse stretching. In another method, each edge of the film is gripped between a grooved, rotating pulley and an endless belt, which co-operates with the groove over a part of the periphery of the pulley, each pulley being set at an angle to the film so that the distance between the two edges of the film increases as the pulleys rotate. This arrangement will be referred to hereinafter as a "pulley/belt system". When film is moved in such a curved path during drawing, it may be passed over a curved surface, such as the surface of a drum, to prevent sagging of its central portion. It has been proposed to warm the whole of this curved surface to assist drawing of the film. A number of other devices have been proposed for stretching films transversely.

Film which has been drawn in a longitudinal direction may be drawn subsequently in a transverse direction and vice versa.

The degree of orientation produced in the film, and hence the amount of improvement in mechanical strength, depends upon the speed as well as upon the extent of drawing; the greater the speed at which a given draw ratio is introduced into the film, the greater are the resulting molecular orientation and increase in mechanical strength. In longitudinal drawing the whole of the draw is usually localised at a line across the width of the film, and hence occurs at the maximum obtainable speed. In transverse drawing by known methods, on the other hand, the drawing has been distributed over the whole of the area of the film under tension for the whole of the time of drawing, and the maximum improvement in properties that is theoretically obtainable for a given draw ratio has not been realised.

It is an object of the present invention to provide an improved process for the continuous, transverse cold-drawing of film of organic thermoplastic materials, and parti-

cularly to provide a process which enables drawn film to be made with high mechanical strength for a given transverse draw ratio. Another object is to provide improved apparatus for cold-drawing film of organic thermoplastic material.

According to the present invention, a process in which film of organic thermoplastic material is continuously transversely drawn, by forces applied to its edges, while it is heated to a temperature that promotes drawing, is characterised in that, during the transverse drawing process:

(*a*) All points across the width of the film are eventually heated to a temperature that promotes drawing but each point in a width is at such a temperature for only a part of the total period during which such width of film is being drawn.

(*b*) Only a fraction of the width of the film is so heated at any one point along the length of the region of transverse drawing; and

(*c*) Throughout the length of the region of transverse drawing of the film there is always at least one region in the width of the film that is at a temperature that promotes drawing.

By this process, each increment in the total width of the film is concentrated in a restricted area of the film. In other words, for any given final draw ratio, the whole increase in total width of the film that takes place over a small part of the length of the drawing region is concentrated in one small part of the width of the film; and at the same time any small part of the width of the film becomes wholly drawn over only a small part of the length of the drawing region. Hence, the speed of drawing and the amount of molecular orientation introduced into each part of the film are greater than could be obtained if the whole width of the film were heated to the drawing temperature for the whole length of the drawing region. It follows that the greatest amount of orientation is obtained when the area of the film that is at drawing temperature at any one time is reduced to a minimum; that is, the best results are obtained by the process of this invention when the heating of the film is localised as much as possible. At the same time, it will be appreciated that, for the production of high quality film, the method of heating must be such as to allow uniform transverse drawing throughout the film, except in the margins which are later to be trimmed off.

It is preferred that each heater used be followed by a cooler of the same form, so that all parts of the film being drawn are maintained for only a very short period at a temperature that promotes drawing.

Our invention also includes apparatus for continuously, transversely stretching a film of organic thermoplastic material, comprising means for gripping or otherwise holding the edges of the material and for separating these edges one from the other to stretch the film, characterised in that it is provided with means for heating the film such that:

(*a*) All points across the width of the film are eventually heated to a temperature that promotes drawing but each point in a width is at such a temperature for only a part of the total period during which such width of film is being drawn.

(*b*) Only a fraction of the width of the film is so heated at any one point along the length of the region of transverse drawing; and

(*c*) Throughout the region of transverse drawing of the film there is always at least one region in the width of the film that is at a temperature that promotes drawing.

For ease of applying and designing the heaters used in the process of our invention it is preferred that the heating pattern that they apply conforms essentially to one or more lines. It is further preferred that there are either one or two lines of heating, and that when there are two lines of heating they are symmetrically disposed on each side of the centre of the film. In this way it is possible by the use of heaters which supply a uniform amount of heat along their length to obtain uniform drawing across the width of the film. It will be appreciated that when a single line heater is used this must extend from one side of the film at, or near, the point where drawing is begun to the other side of the film at, or near, the point where drawing ends; and that when two line heaters are used they must extend either from each side of the film at or near the point where drawing begins to the centre of the film at or near the point where drawing ends, or from the centre of the film at or near the point where drawing begins to the two sides of the film at or near the point where drawing ends.

The method and apparatus of this invention are illustrated diagrammatically by the drawings accompanying the Provisional Specification, in which:

Figures 1 to 3 illustrate the simplest embodiment of our invention, in which film is drawn in a plane by gripping means moving along diverging straight lines on each side of the film;

Figures 4 and 5 show the method of heating film drawn by the pulley/belt system; and

Figure 6 is a perspective illustration of the apparatus of our invention when the drawing means comprises a pulley/belt system and a single line heater is followed by a cooler.

In Figures 1 to 3, which show the type of drawing that occurs in a conventional

tenter or similar tensioning apparatus, AB represents the line at which drawing begins and A'B' the line at which it is completed. The dotted lines represent lines along which the film is uniformly heated to a temperature that promotes drawing. Under uniform conditions of feed. take-off and heating, drawing occurs only at the lines of heating shown and uniform drawing occurs along these lines, so that at the completion of drawing the film is uniformly drawn across its width. XYZ then represents the movement of points of material of the film in various circumstances. The Figures thus show that, under these conditions, points on the film that are not separated from one edge by a line of heaters can be represented as moving parallel to that edge, and that when the film is drawn symmetrically on each side and heated symmetrically by two lines of heaters, points on the film between these lines of heaters can be represented as moving at right angles to the lines AB and A'B', or parallel to the longitudinal axis of the film.

Figures 4 and 5, in which the symbols have the same meaning as in Figures 1 to 3, show how the above considerations may be used to obtain to a first approximation the curve for a heating unit or units for use in processes in which the film is drawn in a non-linear manner. Thus, with a single line heater extending from A' to B across the film, as represented in Figure 4, points on the film travelling from the marked positions X, X' etc., to the marked positions Z, Z', etc. (corresponding positions in each of these series being spaced in proportion to the initial and final widths of the film) will first travel along curves of the same form as the corresponding part of the curve A—A', and after crossing the heater will travel along curves of the same form as the corresponding part of the curve B—B'. Therefore, the required line of heating will be along the points of intersection of the two series of curves through corresponding points across the width of the film. Similarly, using two heaters as shown in Figure 5, points passing from X, X', etc., to Z, Z', etc., will at first travel along curves of the same form as the corresponding part of the curves A—A' (on the left) and B—B' (on the right) and after crossing the heaters will travel along lines parallel with the axis of the film. Therefore, the required lines of heating will be through the points of intersection of the curves from X, X', etc., with parallel lines from the corresponding positions Z, Z', etc.

One example of a non-linear drawing method of this type is the pulley/belt system referred to hereinbefore, and diagrammatically illustrated in Figure 6. In this figure, 1 represents a continuous length of film which passes over an idler roll, 2; thereafter its edges are gripped between the endless belts 3 and 3' and the grooved pulleys 4 and 4', over the lower half of the circumferences of the pulleys. The film then passes over idler roll 5. The axes of the pulleys are at a sufficient angle to one another for the points at which the film is withdrawn from them to be three times as far apart as the points at which film is fed to them. The belts 3 and 3' are held under tension around pulleys 7, 8 and 9, and 10, 11 and 12 respectively. 6 is the heater, which makes contact with the lower surface of the advancing film, over a narrow path, from a point adjacent to the edge of the film as it is first gripped between the pulley 4 and the belt 3, to a point adjacent to the edge of the film as it is released from between the pulley 4' and the belt 3'. The curved path to be followed by the heater between these points is determined by the method described above with reference to Figure 4. A cooler, 13, following the same curve, is placed immediately beyond the heater in the manner shown.

It will be appreciated that, in applying the process of this invention, each portion of the film undergoing drawing cannot be heated to the drawing promoting temperature, drawn and cooled again instantaneously; therefore, if the lines of heating described above are followed exactly this may result in different drawing conditions between those parts of the film where the heater is near the beginning of drawing, where it is near the end of drawing and where it is an intermediate position. The extent of this difference will depend upon the method and degree of heating applied, the material of the film, the rate at which the film is passed through the equipment, and the draw ratio. What has been set out concerning the design of the heater therefore only approximates to any requirement for obtaining film which is uniformly drawn across its width, and if a high degree of uniformity is required adjustments to the design of the heater should be made by trial and error. This correction from the previously described lines of heaters is particularly necessary when the material of the film is one in which there is a gradual increase in the ease of drawing with rise in temperature and when the heaters are not followed by coolers. Moreover, the point at which drawing begins is often slightly beyond the point to which heat is applied; it may therefore be necessary to set the heaters back slightly towards the direction of feed of the film.

The film may travel in contact with or close to the heater or heaters. Suitable heaters which may be used include, for example: a hot metal wire bent to the

required shape, in coiled form if desired, supported at intervals along its length; a tubular metal heater containing hot liquid, which is shaped to conform to the surface of the film being drawn; a hot air knife which comprises a slit orifice through which a jet of hot air may be directed on to the film surface; or a heater from which infra-red rays may be directed on to the film surface, for example by means of a suitably disposed diaphragm and/or mirror.

Suitable coolers for use as described comprise, for example, a metal tube through which cooling fluid, normally water, is continuously passed, or a cold air knife, consisting of a slit orifice through which a jet of cold air is directed on to the film surface.

The organic thermoplastic materials which may be cold-drawn in accordance with the present invention are those which are produced in film form in a substantially amorphous state and may be converted into a substantially crystalline state, for example: polystyrene; polyvinylidene chloride; polyacrylonitrile; the firm and fibre forming polyamides; and the film and fibre forming aromatic superpolyesters, such as polyethylene terephthalate.

The process of the present invention is particularly effective for drawing organic thermoplastic materials which show a marked increase at an elevated temperature in the ease with which they can be drawn; it is particularly useful for drawing polyethylene terephthalate, for which the temperature of heating for greatest ease of drawing is between 70° C. and 120° C., usually about 80° C. For such materials, it is often desirable to preheat the film to slightly below the draw promoting temperature immediately before applying the process of this invention. In this way, final heating and drawing can be carried out particularly rapidly and efficiently, especially if coolers are provided beyond the heaters used in the process.

If desired, the film to be drawn by the process of the present invention may already have been drawn longitudinally, or the film may first be drawn according to the present process and thereafter drawn longitudinally.

This process is not limited to the treatment of film formed as a flat sheet, but may also be applied to flattened tubular film.

Our invention is illustrated but in no way limited by the following Example.

Example.

Using the apparatus described hereinbefore and illustrated in Figure 6, the edges of a film of polyethylene terephthalate, 3 in. wide and 0·003 in. thick, were gripped by two pulleys 12 ins. in diameter, which were inclined at such an angle that 9 in. wide film was withdrawn from points on the circumference of the pulleys which were diametrically opposite the points at which the film was initially gripped by them. The heater, which consisted of an electric heating element $^{3}/_{16}$ in. in diameter, bent to the shape shown and hereinbefore described, heated the film surface locally to a temperature of 85° C. The cooler placed immediately after the heater consisted of a shaped metal tube through which cold water was continuously passed. The drawn film obtained after trimming off the edges gripped by the belt was uniform in thickness and appearance. It had a higher mechanical strength in the transverse direction than could be obtained by drawing the film by means of the same apparatus, but omitting the heater and, instead, immersing the apparatus in a heated liquid to a depth great enough to cover at least the lower halves of the pulleys.

What we claim is:—

1. A process in which film of organic thermoplastic material is transversely drawn, by forces applied to its edges, while it is heated to a temperature that promotes drawing, characterised in that:

(*a*) All points across the width of the film are eventually heated to a temperature that promotes drawing but each point in a width is at such a temperature for only a part of the total period during which such width of film is being drawn.

(*b*) Only a fraction of the width of the film is so heated at any one point along the length of the region of transverse drawing; and

(*c*) Throughout the region of transverse drawing of the film there is always at least one region in the width of the film that is at a temperature that promotes drawing.

2. A process according to Claim 1 in which the heating pattern applied to the film is designed substantially as hereinbefore described to promote uniform drawing across the whole width of the drawing region.

3. A process according to Claim 1 or Claim 2 in which the heating pattern applied to the film conforms essentially to one or more lines of uniform heating.

4. A process according to Claim 3 in which the heating pattern conforms to one line extending from one side of the film at or near the point where transverse drawing is begun to the other side of the film at or near the point where transverse drawing ends.

5. A process according to Claim 3 in which the heating pattern conforms essentially to two lines symmetrically disposed on each side of the centre of the film, one line extending from each side of the film

at or near the point where transverse drawing is begun to the centre of the film at or near the point where transverse drawing ends.

6. A process according to Claim 3 in which the heating pattern conforms essentially to two lines symmetrically disposed on each side of the centre of the film, the two lines extending from the centre of the film at or near the point where transverse drawing begins to opposite sides of the film at or near the point where transverse drawing ends.

7. A process according to any of the preceding claims in which the film has been preheated to a temperature slightly below the temperature that promotes drawing.

8. A process according to any of the preceding claims in which the heaters used to apply the heating pattern to the film are followed by coolers of the same form.

9. A process according to any of the preceding claims in which the film is transversely drawn by means of a tenter or like apparatus.

10. A process according to any of Claims 1 to 8 in which the film is transversely drawn by means of a pulley/belt system substantially as hereinbefore described.

11. A process according to any of the preceding claims in which the organic thermoplastic material is polyethylene terephthalate.

12. A process according to Claim 11 in which the film is heated, to promote drawing, to a temperature between 70° C. and 120° C., preferably about 80° C.

13. A process for transversely drawing film substantially as described in the foregoing Example.

14. Films of organic thermoplastic materials that have been cold-drawn by a process according to any of the preceding claims.

15. Apparatus for continuously, transversely stretching a film of organic thermoplastic material, comprising means for gripping or otherwise holding the edges of the material and for separating these edges one from the other to stretch the film, characterised in that it is provided with means for heating the film such that:

(*a*) All points across the width of the film are eventually heated to a temperature that promotes drawing but each point in a width is at such a temperature for only a part of the total period during which such width of film is being drawn.

(*b*) Only a fraction of the width of the film is so heated at any one point along the length of the region of transverse drawing; and

(*c*) Throughout the region of transverse drawing of the film there is always at least one region in the width of the film that is at a temperature that promotes drawing.

16. Apparatus according to Claim 15 in which said means for heating the film comprise one or more line heaters capable of supplying a uniform amount of heat along their length.

17. Apparatus according to Claim 15 or Claim 16 in which the means for gripping the film is a tenter or like stretching means.

18. Apparatus according to Claim 15 or Claim 16 in which the means for gripping the film is a pulley/belt system substantially as hereinbefore described.

19. Apparatus for continuously, transversely stretching a film of organic thermoplastic material, substantially as hereinbefore described with reference to the accompanying drawings.

ALFRED O. BALL,

Agent for the Applicants.

PROVISIONAL SPECIFICATION.

Improvements in and relating to the Manufacture of Films.

We, IMPERIAL CHEMICAL INDUSTRIES LIMITED, of Imperial Chemical House, Millbank, London, London, S.W.1, a British Company, do hereby declare this invention to be described in the following statement:

This invention relates to a process for cold-drawing films of organic thermoplastic material. By the term "cold-drawing" as used throughout this Specification, we mean stretching the film at a temperature below the melting point of the thermoplastic material. The purpose of cold-drawing is to cause molecular orientation in the film and in this way improve its properties.

It is known that such films may be drawn longitudinally, e.g. by passing them from one set of pinch rolls to a second set of pinch rolls operating at higher speeds. This is, however, merely a one-direction orientation and the strength of the film is increased solely in the direction of draw. It is preferred that the orientation of films should be both longitudinal and lateral as the film then shows improved properties in all directions over its surface. Transverse, i.e. lateral, drawing may be carried out by gripping the edges of film and gradually spreading the same apart as it moves along a given path.

The equipment used for gripping the film may take a number of different forms. For example, tenter clips or hooks may be adapted to hold the edges of the film and thereafter diverge at a predetermined rate to impart the desired amount of transverse stretching. Alternatively, to obtain the desired transverse stretching, each edge of the film may be gripped between the periphery of a grooved pulley, set at an angle to the direction of travel of the film, and an endless belt adapted to co-operate with the groove, in the pulley over a part of its periphery. This arrangement will be referred to hereinafter as a "pulley/belt system". When film is moved in such a curved path during drawing, it may be dragged over a curved surface, e.g. that of a drum, to prevent sagging of its central portion. A number of other devices have been proposed for stretching films transversely.

Film which has been drawn in a longitudinal direction may be drawn subsequently in a transverse direction and vice versa. The film may advantageously be heated during drawing.

One object of the present invention is to provide an improved process for the continuous, transverse, cold-drawing of film of organic thermoplastic materials. In particular, our process enables drawn film to be made with high mechanical properties for given draw ratios. Another object is to provide improved apparatus for cold-drawing film of organic thermoplastic material.

According to the present invention, we provide a process in which film of organic thermoplastic material is passed through equipment which holds the edges of the film and stretches the film transversely while it is so held, characterised in that:

(*a*) All points across the width of the film are heated to a temperature which promotes drawing and are each at such temperature during a part, preferably a very small part, of the period in which the film is being drawn.

(*b*) Heat applied to the film at any stage in its passage through the equipment is applied to only a small fraction of the width of the film, and

(*c*) The film is locally heated to a temperature which promotes drawing throughout that part of its length which is subjected to drawing during its passage through the equipment.

Our invention also includes apparatus comprising equipment for holding the edges of film and stretching the film transversely while it is so held and means adapted to heat all points across the width of the film to a temperature which promotes drawing, the points reaching such temperature within the region in which the film is being drawn, this heating being in such a manner that only a small fraction of the width of the film is heated at any stage in the passage of the film through the equipment, and that all parts of the length of the film being drawn are heated locally to a temperature which promotes drawing.

For ease of applying and designing the heaters of our invention it is preferred that the heating pattern which they apply conforms essentially to one or more lines. It is further preferred that there are either one or two lines of heating and that when there are two lines of heating they are symmetrically disposed on either side of the centre of the film. In this way it is possible to use heaters which apply the same amount of heat along their length and obtain a uniform degree of draw across the width of the film. It will be appreciated that with a single line heater, such a heater must extend from one side of the film, at or near, the point where drawing is commenced to the other side of the film at, or near, the point where drawing ends, and that in the case of two lines of heating they must extend either from both sides of the film at, or near, where drawing commences to the centre of the film at, or near, where drawing ends or from the centre of the film at, or near, where drawing commences to the two sides of the film at, or near, where drawing ends.

The method and apparatus of this invention are illustrated diagrammatically by the accompanying drawings, in which:—

Figures 1—3 illustrate film being drawn transversely by means of tenter clips or hooks (not shown). In these figures AB represents the line at which drawing commences and A^1B^1 the line at which it is completed. The dotted lines represent lines along which the film is heated to a temperature which promotes drawing. If conditions of feed, take-off, and heating are such that drawing occurs only at the lines of heating shown and uniform drawing occurs along these lines, so that at the completion of drawing the film is uniformly drawn across its width, XYZ represents the movement of points of material of the film in various circumstances. This shows that, under these conditions, the material of the film which is not separated from one set of tenters by a line of heaters moves parallel to those tenters, and that when the film is drawn symmetrically on either side and heated symmetrically by two lines of heaters, the material of the film between these lines of heaters moves at right angles to the lines of feed and take-off.

Figures 4 and 5, in which the symbols have the same meaning as in Figures 1—3, show how the above considerations may be used, by following the desired movement of various points on the film, to obtain a first

approximation the curve for a heating unit or units when film is drawn in a non-linear manner, e.g. by means of a pulley/belt system, and the film passes over a drum to prevent sagging of its central portion.

It is preferred that the heater or heaters of our invention are followed by a cooler or coolers so all parts of the film being drawn are maintained for only a very short period at a temperature which promotes drawing.

Figure 6 is a perspective illustration of the apparatus of our invention when the drawing means comprises a pulley/belt system and a single line heater is followed by a cooler.

A continuous length of film, 1, passes over idler roll, 2, and thereafter its edges are gripped between the endless belts 3 and 3' and the grooved pulleys 4 and 4' over the lower half of their circumferences, before is passes over idler roll 5. The axes of the pulleys are at a sufficient angle to one another for the points at which the film is withdrawn from them to be three times as far apart as the points at which film is fed to them. The belts 3 and 3' are held under tension around pulleys 7, 8 and 9 and 10, 11 and 12 respectively. 6 is the heater which makes contact with the lower surface of the advancing film, over a narrow path, from a point adjacent to the edge being gripped by the pulley 4 and the belt 3, as it descends from pulley 7, to a point adjacent to the edge being gripped by the pulley 4' and the belt 3', as it rises over pulley 11. A cooler, 13, is placed immediately following the heater in the manner shown.

The organic thermoplastic materials which may be cold-drawn in accordance with the present invention are those which are produced in film form in a substantially amorphous state and may be converted into a substantially crystalline state, such as, e.g. polystyrene, polyvinylidene chloride, polyacrylonitrile, the fibre-forming polyamides and the fibre-forming aromatic superpolyesters, e.g. polyethylene terephthalate.

The process of the present invention is particularly effective for drawing organic thermoplastic materials which show a marked increase at an elevated temperature in the ease with which they can be drawn, e.g. for drawing polyethylene terephthalate, for which the temperature of heating for ease of drawing is between 70° C. and 120° C., e.g. about 80° C.

It is desirable, in the case of film of material which shows a marked increase in the case with which it may be drawn at an elevated temperature, to preheat the film material to slightly below this temperature prior to applying the heating of this invention. In this way, heating to a temperature which promotes drawing, drawing and cooling to below this temperature can be as rapid as possible, particularly so, of course, if there is a cooler or coolers placed after the heater or heaters of this invention.

It will be appreciated that each portion of the film undergoing drawing will not be heated to the drawing promoting temperature, drawn and cooled again instantaneously, and that if the lines of heating described above are followed this will result in different drawing conditions between those parts of the film where (*a*) the heater is near the commencement of drawing, (*b*) where the heater is near the end of drawing and (*c*) the intermediate parts. The extent of this difference will depend upon the method and degree of heating applied, the organic thermoplastic material of the film, the rate at which the film is passed through the equipment, the degree of drawing and the variation of drawing as the film passes through the equipment. What has been set out concerning the design of the heater, therefore, only approximates to any requirement for obtaining film which is uniformly drawn across its width, and if a high degree of uniformity is required adjustments to the design of the heater should be made by trial and error. This correction from previously described lines of heaters is particularly necessary when the material of the film is one in which there is a gradual increase in the ease of drawing with rise in temperature and when the heater or heaters are not followed by a cooler or coolers.

The film may travel in contact with or in close proximity to the heater or heaters. Suitable heaters which may be used include, for example, a hot metal wire bent to the required shape, if desired, in coiled form, supported at intervals along its length, or a tubular metal heater containing hot liquid, which is shaped to conform to the surface of the film being drawn. Another method of heating the film consists in the use of a hot air knife which comprises a slit orifice through which a jet of hot air may be forced on to the film surface. Yet another method of heating the film comprises using infrared rays which may be directed on to the film surface, e.g. by means of a suitably disposed diaphragm and/or mirror.

Suitable coolers for use as described comprise, for example, a metal tube through which cooling fluid, normally water, is continuously passed, or a cold air knife, consisting of a slit orifice through which a jet of cold air is directed on to the film surface.

If desired, the film to be drawn by the process of the present invention may already have been drawn longitudinally or, alternatively, the film may first be drawn according to the present process and thereafter drawn longitudinally.

This process is not limited to the treatment

of ordinary film, but may also be applied to flattened tubular film.

Our invention is illustrated but in no way limited by the following Example.

EXAMPLE.

Using the apparatus described hereinbefore and illustrated in Figure 6, the edges of a film of polyethylene terephthalate, 3" wide and 0.003" thick, were gripped by two pulleys 12" in diameter, which were inclined at such an angle that 9" wide film was withdrawn from points on the circumference of the pulleys which were diametrically opposite the points at which the film was initially gripped by them. The heater, which consisted of an electric heating element, $^3/_{16}$" in diameter, bent to the shape shown, presented a surface temperature of 85° C. to the moving film. The cooler placed immediately after the heater consisted of a shaped metal tube through which cold water was continuously passed.

ALFRED O. BALL,
Agent for the Applicants.

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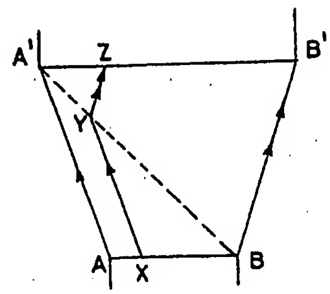

FIG. 1.

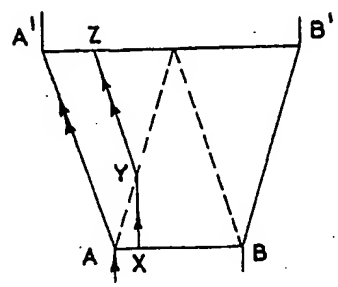

FIG. 2.

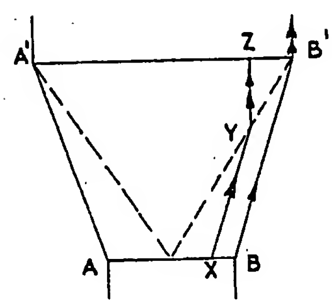

FIG. 3.

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3 SHEETS

This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

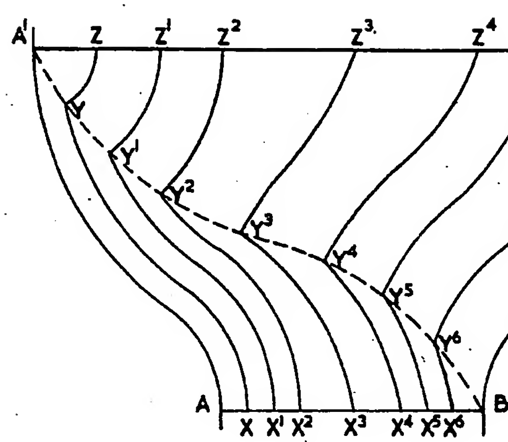

FIG. 4.

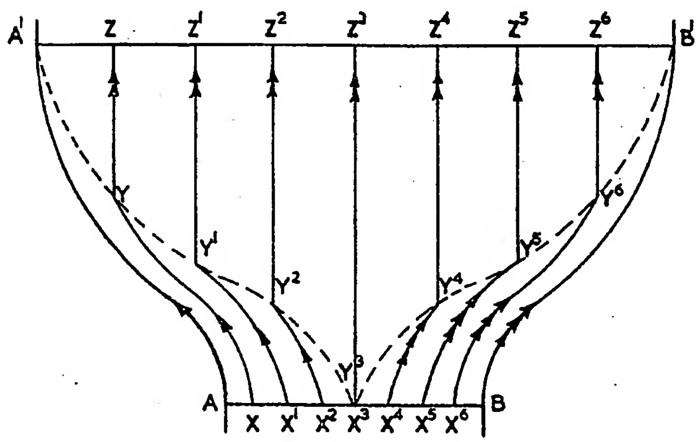

FIG. 5.

753,603 PROVISIONAL SPECIFICATION
3 SHEETS

This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

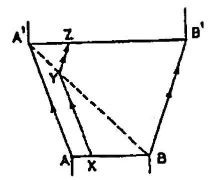

FIG.1.

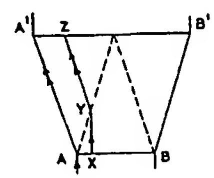

FIG.2.

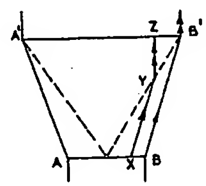

FIG.3.

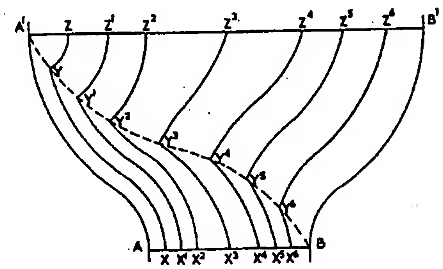

FIG. 4.

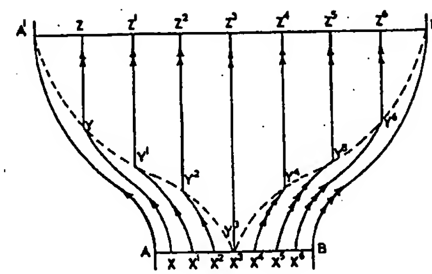

FIG. 5.

753,603 PROVISIONAL SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale.*
SHEET 3

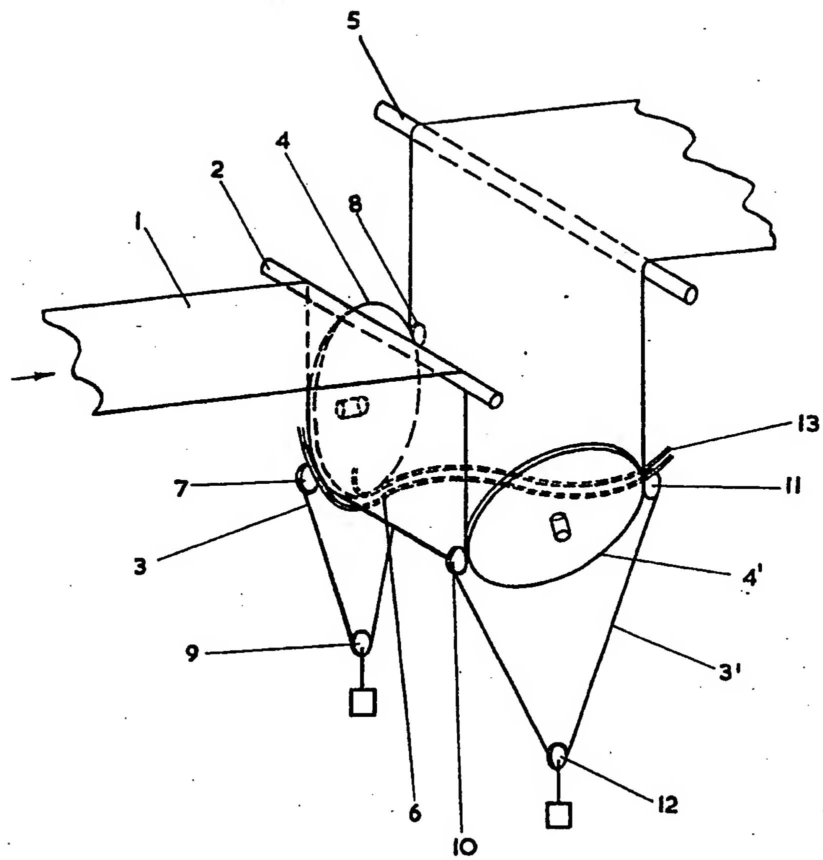

FIG.6.